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M04/420/H(2)M+

MARKSCHEME

May 2004

CHEMISTRY

Higher Level

Paper 2

General Marking Instructions

This in the ONLY mark scheme released for this session.

Note:
Please use a personal courier service when sending sample materials to TLs unless postal services can be guaranteed. Record the costs on your examiner claim form.

1. Follow the markscheme provided, do **not** use decimals or fractions and mark only in **RED**.

2. Where a mark is awarded, a tick (✓) should be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark.

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation in the **left hand margin** to explain your decision. You are encouraged to write comments where it helps clarity, especially for moderation and re-marking.

4. Unexplained symbols or personal codes/notations on their own are unacceptable.

5. Record subtotals (where applicable) in the right-hand margin against the part of the answer to which they refer (next to the mark allocation for Section A). Do **not** circle sub-totals. **Circle the total mark for the question in the right-hand margin opposite the last line of the answer.**

6. For Section B, show a mark for each part question (a), (b), *etc.*

7. Where an answer to a part question is worth no marks, put a zero in the right-hand margin.

8. Section A: Add together the total for each question and write it in the Examiner column on the cover sheet.
Section B: Insert the total for each question in the Examiner column on the cover sheet.
Total: Add up the marks awarded and enter this in the box marked TOTAL in the Examiner column.

9. After entering the marks on the cover sheet, check your addition to ensure that you have not made an error. Check also that you have transferred the marks correctly to the cover sheet. **We have script checking and a note of all clerical errors may be given in feedback to examiners.**

10. Every page and every question must have an indication that you have marked it. Do this by **writing your initials** on each page where you have made no other mark.

11. If a candidate has attempted more than the prescribed number of questions within a paper or section of a paper, mark only the required number of answers in the order in which they are presented in the script, **unless the candidate has indicated the questions to be marked on the cover sheet**. Make a comment to this effect in the left hand margin.

12. A candidate can be penalized if he/she clearly contradicts him/herself within an answer. Make a comment to this effect in the left hand margin.

Subject Details: Chemistry HL Paper 2 Markscheme

General

- Each marking point is usually shown on a separate line or lines.
- Alternative answers are separated by a slash (/) – this means that either answer is acceptable.
- Words underlined are essential for the mark.
- Material in brackets (…) is not needed for the mark.
- The order in which candidates score marks does not matter (unless stated otherwise).
- The use of **OWTTE** in a markscheme (the abbreviation for "or words to that effect") means that if a candidate's answer contains words different to those in the markscheme, but which can be interpreted as having the same meaning, then the mark should be awarded.
- Please remember that many candidates are writing in a second language, and that effective communication is more important than grammatical accuracy.
- In some cases there may be more acceptable ways of scoring marks than the total mark for the question part. In these cases, tick each correct point, and if the total number of ticks is greater than the maximum possible total then write the maximum total followed by **MAX**.
- In some questions an answer to a question part has to be used in later parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in later parts then "follow through" marks can be scored. Show this by writing **ECF** (error carried forward). This situation often occurs in calculations but may do so in other questions.
- Units for quantities should always be given where appropriate. In some cases a mark is available in the markscheme for writing the correct unit. In other cases the markscheme may state that units are to be ignored. Where this is not the case, penalize the omission of units, or the use of incorrect units, once only in the paper, and show this by writing **–1(U)** at the first point at which it occurs.
- Do not penalize candidates for using too many significant figures in answers to calculations, unless the question specifically states the number of significant figures required. If a candidate gives an answer to fewer significant figures than the answer shown in the markscheme, penalize this once only in the paper, and show this by writing **–1(SF)** at the first point at which this occurs.
- If a question specifically asks for the name of a substance, do not award a mark for a correct formula; similarly, if the formula is specifically asked for, do not award a mark for a correct name.
- If a question asks for an equation for a reaction, a balanced symbol equation is usually expected. Do not award a mark for a word equation or an unbalanced equation unless the question specifically asks for this. In some cases, where more complicated equations are to be written, more than one mark may be available for an equation – in these cases follow the instructions in the markscheme.
- Ignore missing or incorrect state symbols in an equation unless these are specifically asked for in the question.
- Mark positively. Give candidates credit for what they have got correct, rather than penalizing them for what they have got wrong.
- If candidates answer a question correctly, but by using a method different from that shown in the markscheme, then award marks; if in doubt consult your Team Leader.

SECTION A

1. (a) (order with respect to) $NO = 2$;
(order with respect to) $H_2 = 1$;
rate increases $\times 4$ when [NO] doubles / *OWTTE*; ***[3]***

(b) $\text{rate} = k[NO]^2[H_2]$; ***[1]***
ECF from (a).

(c) $(2.53\times10^{-6}\ \text{mol dm}^{-3}\ \text{s}^{-1} = k\ (0.100\ \text{mol dm}^{-3})^2(0.100\ \text{mol dm}^{-3}))$
$k = 2.53\times10^{-3}$; ***[1]***
$\text{mol}^{-2}\ \text{dm}^6\ \text{s}^{-1}$; ***[1]***
ECF from (b).

(d) agrees / yes;

slow step depends on X and NO;
X depends on H_2 and NO;
(so) NO is involved twice and H_2 once;
Overall equation matches the stoichiometric equation;
*Award **[1]** each for any three of the four above.*

OWTTE
ECF for "no", depending on answer for 1 (b). ***[4 max]***

Or agrees / yes;
and $\frac{[X]}{[H_2][NO]} =$ constant;
rate of slow step $= k[X][NO]$
$= k[H_2][NO]^2$;
ECF for "no", depending on answer for 1 (b). ***[4]***

(e) reaction involves <u>four</u> molecules;
statistically / geometrically unlikely; ***[2]***

(f) the rate of formation of $H_2O(g) = 2\times$ rate for $N_2(g)$;
because 2 moles H_2O formed with 1 mole N_2 / *OWTTE*; ***[2]***

2. (a) $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$; ***[2]***

*Award **[1]** for formulas and **[1]** for coefficients.*

(b) $(CO_2 \text{ produced}) = 200\ (cm^3)$;

$(O_2 \text{ remaining}) = 100\ (cm^3)$; ***[2]***

ECF from 2(a).

3. (a) $Zn + I_2 \rightarrow ZnI_2$; ***[1]***

Accept equilibrium sign.

(b) (moles of) zinc $\left(= \dfrac{100.0\ g}{65.37\ g\ mol^{-1}} \right) = 1.530$;

(moles of) iodine $\left(= \dfrac{100.0\ g}{253.8\ g\ mol^{-1}} \right) = 0.3940$;

ECF throughout.
-1 (*SF*) *possible.*

(reacting ratio is 1:1, therefore) zinc is in excess; ***[3]***

Must be consistent with calculation above.

(c) (amount of zinc iodide = amount of iodine used $= \dfrac{100.0}{253.8}$ moles)

(mass of zinc iodide $= \dfrac{100.0}{253.8} \times (65.37 + 253.8) =$) 125.8 (g) ; ***[1]***

Use ECF throughout.
-1 (*SF*) *possible.*

4. (a) atoms of the same element / same atomic number / same number of protons;
different numbers of neutrons / mass numbers; ***[2]***
*Award only **[1]** max if reference made to elements but not atoms.*

(b) relative atomic mass $= \frac{(69 \times 61.2 + 71 \times 38.8)}{100} = 69.8$; ***[1]***
-1 (*SF*) *possible (treat 69 and 71 as integers)*

5. (a) continuous spectrum has all colours / wavelengths / frequencies whereas line spectrum has only (lines of) sharp / discrete / specific colours / wavelengths / frequencies; ***[1]***

(b) lines get closer together towards high energy; ***[1]***

(c) line represents electron transitions between energy levels / *OWTTE*; ***[1]***

6. (a) molecules move from ice to water and water to ice / $H_2O(s) \rightleftharpoons H_2O(l)$ / *OWTTE mentioning particles / molecules*;

at the same rate; ***[2]***

(b) molecules leave skin surface / evaporate / intermolecular forces are overcome on evaporation;
causing cooling effect / heat taken from skin / endothermic process; ***[2]***

7. *No ECF throughout this question*.

(a) $K_c = \frac{[N_2O_4]}{[NO_2]^2}$; ***[1]***

(b) K_c decreases;
forward reaction is exothermic / ΔH is negative / equilibrium moves to left / *OWTTE*; ***[2]***

(c) (mixture will get) darker / darker than expected;

equilibrium position moves to the left / towards reactants as there is an increase in the number of moles of gas from right to left; ***[2]***

(d) (equilibrium mixture contains) less (than 2 moles NO_2);
given values make $\frac{[N_2O_4]}{[NO_2]^2} = \frac{1}{2}$ *i.e.* too much NO_2 / *OWTTE*; ***[2]***

SECTION B

8. (a) (i) $1s^2 2s^2 2p^6 3s^2 3p^6$; ***[1]***

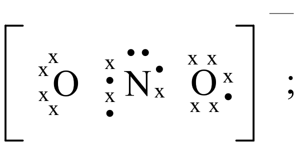
Do not accept [Ne] $3s^2 3p^6$ or 2, 8, 8.

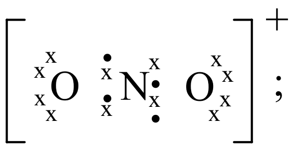
(ii) K^+ / Ca^{2+} / Sc^{3+} / Ti^{4+};

Cl^- / S^{2-} / P^{3-} ; ***[2]***

Accept other suitable pairs of ions.

(b)





Accept lines for pairs of electrons.
If charge is missing, penalize only once.

ion	shape	explanation
NO_2^-	bent / angular;	three charge centres one of which is a lone / non-bonding pair / *OWTTE*;
NO_2^+	linear;	two charges centres / *OWTTE*;

[6]

(c) (i) $C_2H_6 < CH_3CHO, < C_2H_5OH < CH_3COOH$; ***[2]***

*Award **[2]** if all correct, **[1]** if first and last correct.*

(ii) C_2H_6 non polar;

CH_3CHO polar;

C_2H_5OH polar;

CH_3COOH polar;

*Award **[2]** for all four correct, **[1]** for 3 or 2 correct.*

boiling point depends on intermolecular forces;
least energy required for van der Waals' forces / maximum energy for hydrogen bonding;
C_2H_6 van der Waals' forces only;
CH_3CHO dipole-dipole;
C_2H_5OH and CH_3COOH hydrogen bonding;
hydrogen bonding is stronger in CH_3COOH / greater polarity / greater molecular mass / greater van der Waals' forces; ***[8]***

(d) (i) *diamond*
non conductor;
no free electrons;

graphite
good conductor;
free electrons / delocalized electrons; ***[4]***

(ii) conducts when molten / in aqueous solution;
ions can move; ***[2]***

9. (a) a reaction is spontaneous when $\Delta G^{\ominus}$ is negative;

at high T, $\Delta G^{\ominus}$ is negative;
$-T\Delta S^{\ominus}$ is larger / greater than $\Delta H^{\ominus}$;
at low T, $\Delta G^{\ominus}$ is positive because $-T\Delta S^{\ominus}$ is smaller than $\Delta H^{\ominus}$ / *OWTTE*; ***[4]***

(b) (i) ΔH = (sum of energies of bonds broken) – (sum of energies of bonds formed);
Can be implied by working.

Correct substitution of values and numbers of bonds broken;
Correct substitution of values and numbers of bonds made;

$(\Delta H = (\mathrm{N{\equiv}N}) + 3(\mathrm{H{-}H}) - 6(\mathrm{N{-}H}) = 944 + 3(436) - 6(388) =) -76$ (kJ); ***[4]***
Allow ECF.
Do not penalize for SF or units.

(ii) $\Delta S^{\ominus}$ = (sum of entropies of products) – (sum of entropies of reactants);
Can be implied by working.

$(= 2\times192 - (193 + 3\times131) =) -202$ (J K^{-1} mol^{-1});
four molecules make two molecules / fewer molecules of gas; ***[3]***

(iii) $(\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus} = -76.0 - 300(-0.202)) = -15.4$ (kJ mol^{-1}); ***[1]***
Do not penalize for SF.

(iv) $\Delta H^{\ominus}$ becomes more negative;
heat released when gas → liquid; ***[2]***

(c) enthalpy change associated with the formation of one mole of a compound / substance;
from its elements;
in their standard states / under standard conditions;

$2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$; ***[5]***
*Award **[1]** for formulas and coefficients, **[1]** for state symbols.*

(d) bond enthalpy is the energy required to break a mole of bonds;
Ignore any mention of state.

the average of the enthalpies for a specific bond in a variety of compounds; ***[2]***

(e) cyclohexane has single bond of same length / strength;
benzene has delocalized / resonance structure;
immediate length / strength / 1.5 bond order;
can use average bond enthalpies for cyclohexane / not for benzene;
OWTTE. ***[4]***

10. (a) (i) $([H^+]=)1\ mol\ dm^{-3}$;
298 K / 25 °C;
1 atm / 101.3 or 101 kPa
Accept 100 kPa; ***[3]***

(ii) $E^{\ominus}(=0.76+0.34)=(+)1.1(0)(V)$;
from zinc / Zn to copper / Cu;
copper / Cu deposited / electrode becomes larger / thicker / heavier;
zinc / Zn electrode becomes smaller / thinner / lighter;
Cu^{2+} solution becomes paler / colourless; ***[5]***
Allow ECF for -1.1 V, all answers must be consistent with the error.

(b) no (spontaneous) reaction;
appropriate use of Table 15 / $E^{\ominus}=-0.34+0.00=-0.34\ V$ / $E^{\ominus}$ value for the reaction would be negative; ***[2]***

(c) O_2 / $Cr_2O_7^{2-}$;
Accept names.

$E^{\ominus}$ value for the reaction with Br^- is positive / suitable calculation to show this;
$E^{\ominus}$ value for the reaction with Cl^- is negative / Cl_2 stronger oxidizing agent than O_2 / $Cr_2O_7^{2-}$;
$4Br^- + O_2 + 4H^+ \rightarrow 2Br_2 + 2H_2O$ / $Cr_2O_7^{2-} + 14H^+ + 6Br^- \rightarrow 2Cr^{3+} + 7H_2O + 3Br_2$; ***[5]***
*Award **[1]** for all formulas correct, **[1]** if coefficients correct.*

(d) sodium at negative electrode / cathode;
chlorine at positive electrode / anode;
Accept Na and Cl_2 but not Cl.
*Award **[1]** if electrodes not named or correct products at wrong electrodes.*
$Na^+ + e^- \rightarrow Na$;
$2Cl^- \rightarrow Cl_2 + 2e^-$;
$Na : Cl_2$ in ratio $2:1$; ***[5]***

(e) (i) hydrogen and chlorine;
Accept formulas.
(ratio) $1:1$; ***[2]***

(ii) hydrogen and oxygen;
Accept formulas.
($H_2 : O_2$ in ratio) $2:1$; ***[2]***

(iii) $2H^+ + 2e \rightarrow H_2$ /
$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ /
$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ /
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$. ***[1]***
Accept $2Cl^- + 2H_2O \rightarrow H_2 + Cl_2 + 2OH^-$

11. (a) (i) **C** is CH_3CH_2CHO;
D is CH_3CH_2COOH;
Penalize once for missing H atoms in the detailed structure.

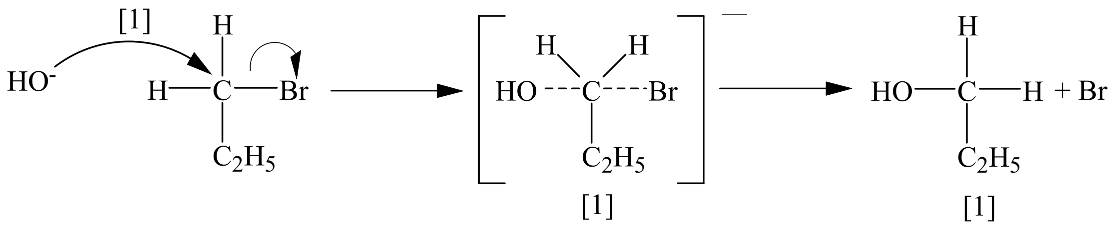
($3:2:1$ ratio because there are) three different hydrogen environments;
with 3 H in one, 2 H in another and 1 H in a third environment;
$1700\ cm^{-1}$ is due to presence of $C=O$; ***[5]***

(ii) $1000-1300$ (cm^{-1} from C—O bond);
$2500-3300$ (cm^{-1} from O—H); ***[2]***

(b) $CH_3CH_2CH_2OH$;
$3:2:2:1$;
Allow ECF from incorrect structure. ***[2]***

(c) potassium dichromate(VI) / $K_2Cr_2O_7$;
Accept other string oxidizing agents.
acidified / H^+ / sulfuric acid;
distill off the product as it forms / limiting the amount of oxidizing agent / reducing concentrations of acid or oxidizing agent; ***[3]***

(d) substitution;
nucleophilic;
bimolecular / two particles in rate-determining step;
*Award **[2]** for three correct, **[1]** for two correct.*



Suitable diagram with
curly arrow from O of OH^- to C joined to Br;
curly arrow from C—Br bond to Br (this can be on the reagant or on the transition state);
transition state with negative charge and --- bonds to Br and OH;
correct products; ***[6]***

(e) faster (for **A**);
C—Br bond weaker / easier to break than C—Cl bond; ***[2]***
Allow opposite argument for $CH_3CH_2CH_2Cl$ reaction being slower.

(f) esterification / condensation;
$CH_3CH_2COOCH_2CH_2CH_3$; ***[2]***

(g) CH_3COOCH_3 / $HCOOCH_2CH_3$;
no OH group **/ D** has OH group;
no hydrogen bonding possible with water / hydrogen bonding only possible with **D**; ***[3]***